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An Application in Frequency Assignment Based on Improved Discrete Harmony Search Algorithm

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Abstract

In cellular mobile communication network, for using the limited available spectrum to meet the increasing demand of customer, it is important to scheme frequency source by applying some optimized algorithm. To the question, an improved discrete harmony algorithm is proposed, particle location update strategies of the particle swarm optimization algorithm is introduced, the probability of harmony memory size and the probability of pitch adjusting rate are adjusted dynamically, which improve the global optimization stability of the search results, enhance the universality and robustness of the algorithm, and improve the convergence rating and the convergence speed. Simulation results show that the improved algorithm applied to solve the problem of frequency assignment has achieved good results.

Keywords: harmony search algorithm; discrete harmony search; frequency assignment; dynamic adjustment ;

1. Introduction

In the cellular mobile communication network, the available spectrum is limited in scope, with the number of user increased rapidly, how to improve spectrum utilization is a key to the current development of mobile communication, so it requires the frequency resources must be planned reasonably and effectively to meet system capacity. It is an effective way to adopt a better frequency assignment strategy for improving the utilization of available frequency resources. Frequency assignment, also known as channel assignment problem (CAP), belongs to the NP complete combinatorial optimization problems. In the cellular networks, the limited frequency resources are reused effectively, because it has adjacent channel interference and co-channel interference, therefore, it is very important to assign channels optimally. To the question of channel assignment, there are many optimization algorithms at home and abroad, such as simulated annealing, genetic algorithm and neural network algorithms etc [1-7]. However,

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in the process of searching for the most optimal solution, these algorithms have many defects, such as the convergence rate remains low, it is easy to fall into local optimal solution. Therefore, an improved discrete harmony algorithm(IDHA) is proposed, particle location update strategies of The particle swarm optimization algorithm is introduced, the probability of harmony memory size and the probability of pitch adjustment are adjusted dynamically, which improve the global optimization stability of the search results, enhance the universality and robustness of the algorithm, and improve the convergence rating and the convergence speed. Simulation results show that the improved algorithm applied to solve the problem of frequency assignment has achieved good results.

2. Channel assignment

For the channel allocation problem, we represent the solution space F as an n×m decimal matrix, where n is the number of ratio cells and m is the maximum demand channel number of cells. Basic requirements for cellular network are the ability to serve the expected traffic and the avoidance of interference. The first requirement imposes a demand constraint on F. A total of d_i channels are required for cell i. This implies that the total number of non-zeros in row i of F must be d_i, the second requirement is modeled by the compatibility matrix C, where each diagonal element C_{ij} represents the co-site constraint(CSC),each nondiagonal element C_{ij} represents the minimum separation distance in frequency between any two frequencies assigned to cell i and j, respectively. In this matrix, cochannel constraint(CCC) is represented by C_{ij}=1, adjacent channel constraint(ACC) is represented by C_{ij}=2, and cells that are free to us the same channels are represented by C_{ij}=0 [8,9]. Fitness function is defined as follows,

$$C(F) = \sum_{i=1}^{n} \sum_{k=1}^{d_i} \sum_{j=1}^{n} \sum_{l=1}^{d_j} F_{ikjl} \qquad (1)$$

$$F_{ikjl} = \begin{cases} 1 & |f_{ik} - f_{jl}| < C_{ij} \\ 0 & \text{other} \end{cases} \qquad (2)$$

Where fik represent cell i is assigned frequency k, the same means to f_{jl}. When all constraints are met, the fitness value of C (F) is zero. The purpose of CAP problem is to find a solution with a minimum frequency number of to meet C (F) is zero.

3. Harmony search algorithm

3.1. Basic harmony search algorithm

Harmony search algorithm is a heuristic global optimization algorithm [10], the basic idea is the process which the notes is reconciled to achieve optimal performance is simulated. The reconciliation process of playing music can be seen as the optimization process, a variety of instruments will be similar to the various components of the solution which will be optimized. The tone of all kinds of instruments to be equivalent to the solution of problems, the evaluation of harmony will be analogy in fitness function of the corresponding solution. The main algorithm parameters are harmony memory considering rate(HMCR), harmony memory size(HMS) and pitch adjusting rate(PAR).

3.2. Discrete harmony search algorithm

Basic harmony search algorithm has a continuous feature, however, channel assignment is a typical combinatorial optimization problems, if harmony search algorithm is used for the channel allocation, it must be a discrete harmony search algorithm. The generation of discrete harmony as follows:

$$\begin{aligned} X' &= HMCR \otimes (g(X^1, X^2, \cdots X^n), X'') \\ &= \begin{cases} g(X^1, X^2, \cdots X^n) & \textit{if } (r < HMCR) \\ h(g(X^1, X^2, \cdots X^n), X'') & \textit{otherwise} \end{cases} \end{aligned} \qquad (3)$$

Where X″ is a temporary solution, *h*(X)represents new individuals that one harmony variable exchange information with another variable, *g*() represents a new harmony variable generated by interacting all solution.

Harmony disturbance in discrete domain as follows:

$$X' = PAR \otimes F(X'') = \begin{cases} F(X'') & if\ (r < PAR) \\ X'' & otherwise \end{cases} \quad (4)$$

Where F(X') represent the individual variables have disturbance operations.

3.3. An improved discrete harmony search algorithm

Because of HS algorithm converge unstably and is easy to fall into the local optimal solution. To improve stability of global searching result, and enhance universal and robustness of algorithm, harmony search algorithm is improved as follows.

(1)HMCR and PAR adjust dynamically as formulation 5, 6.

$$\mathrm{HMCR} = \mathrm{HMCR}_{\min} + \frac{HMCR_{\max} - HMCR_{\min}}{NI} * n \quad (5)$$

$$PAR = PAR_{\max} - \frac{PAR_{\max} - PAR_{\min}}{NI} * n \quad (6)$$

(2) Refer to particle location update strategy of PSO, the harmony generation way is improved, the most optimal solution in search libraries instead of the temporary solution in formulation 3.

4. The steps of frequency assignment algorithm

Step 1: Initial parameters HMS, Iterations(NI),HMCRmax, HMCRmin, PARmax and PARmin;

Step 2: Initial population, calculate fitness, if result is zero, then exit and output result, otherwise, proceed to Step 3;

Step 3: Generate variable by HMCR, PAR, and randomly selected three rules;

Step 4: Calculate fitness by formulation 3 again. If solution is zeros, then exit and output result, otherwise proceed to Step 3;

Step 5: Algorithm over.

5. Simulation results and comparison

In this paper, an improved harmony search algorithm is used in channel assignment, it adopts real-coded. To verify the performance of channel assignment based on the algorithm, seven well-known benchmark problems is simulated. Table 1 shows these seven questions specifically, all the vectors in table 1can find from [9].Parameters is set as follows: HMS=20, HMCRmax=0.95, HMCRmin=0.5, PARmax=0.9, PARmin=0. 5 and NI=3000, when the maximum number of iterations have not been able to meet the requirements of the solution, we think convergence can not. To verify the convergence rate and convergence speed, each problem runs 40 times. Table 2 describes the result of the algorithm IDHA in this paper compared with other algorithms MGA from [11] and GA from [12], where CR represent convergence rate, ACA represent average convergence algebra.

Table 1. Simulated question specifically

Number of problem	Number of cells	Number of frequencies	Compatibility matrix	Demand vector
1	4	11	C1	D1
2	25	76	C2	D2
3	21	381	C3	D3
4	21	533	C4	D4
5	21	221	C5	D5
6	21	309	C6	D6
7	21	309	C7	D7

Table 2. Simulated question specifically

	MGA		GA	IDHA	
Number of problem	CR(%)	CR(%)	ACA	CR(%)	ACA
1	100	100	0.0	100	0.0
2	100	100	2248.6	100	62.75
3	-	100	34.7	100	15.75
4	-	100	12	100	5.5
5	92	100	136.5	100	38.5
6	-	100	20.2	100	12.5
7	80	98	1977.0	99	78.5

Table 2 shows that the result of question 5 and 7 in [11] is not satisfactory, while use the algorithm, the convergence rate of problem 5 can be to 100%, the problem 7 can reach 99% . The convergence speed of problem 2,⋯,6 is low in [12], when applied the algorithm, not only convergence rate can achieve 100%,but also convergence speed is fast. These experimental results demonstrate that the improved harmony search algorithm has the advantages and feasibility to solve the channel assignment.

6. Conclusions

Harmony algorithm is improved in the paper, particle location update strategies of the particle swarm optimization algorithm is introduced, the probability of harmony memory size and the probability of pitch adjusting rate are adjusted dynamically, which improve the global optimization stability of the search results, enhance the universality and robustness of the algorithm, and improve the convergence rating and the convergence speed. Simulation results show that the improved algorithm applied to solve the problem of frequency assignment has achieved good results.

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